Decision Mechanism, Competition mode and Quality policy

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(This version: June 30, 2008)

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Abstract

This paper proposes a partial equilibrium model of vertical product differentiation to compare minimum quality standards under social welfare maximization and referendum. We also show how the minimum quality standards are altered by the nature of competition in the product market. It is shown that the optimal minimum quality standard is higher under social welfare maximization than under referendum when firms engage in Bertrand competition, but the ranking is reversed when firms engage in Cournot competition. In addition, we have also compared the optimal minimum quality standard under referendum with that under *laisser-faire*. It is found that the former is necessarily higher than the latter, no matter the firms engaged in either Bertrand or Cournot competition.

Keywords: decision mechanisms, minimum quality standards, competition mode

JEL classification: F13, P16

1 Introduction

In the literature on trade and industrial organization, one common assumption is that governments act as social planners, formulating policies in order to pursue social welfare maximization. A social planner, however, connotes dictatorship in the sense that his preference is regarded as social preference. As many governments in the world are in a transitional phase moving from autocracy to democracy, it is conceivable that governments are highly influenced by interest groups and as a result, they serve as policy-executors rather than policy-makers.

Making policies is one of the political rights of people who are both consumers in commodity markets and voters in their democratic society. They have a direct influence on policy formation through referendums. For example, genetically modified organisms (GMO) are disputable on many levels. In a 2005 referendum, a clear majority of Swiss voters approved a five-year ban on the use of GMO.[1] In another referendum, a majority of voters approved the motion that if a perpetrator of violent crimes is certified by expert testimony to be extremely dangerous with no chance of recovery, he may be jailed for life due to the high risk of repeated offences.[2] This illustrates that the Swiss government executes relevant policies strictly on the basis of the outcome of the referendums. In these instances, policies are made by voters rather than by governments who, in practice, merely serve to implement those policies.

The purpose of this paper is to investigate the effects of different decision mechanisms on a country's policy and how they are affected if the firms engaged in

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[1] One of the disputes lies in the fact that GMO have been transferred the worm-resistant genes which result in a massive increase in production. These GMO, however, may cause allergic reactions to human bodies after being consumed. Therefore, the security of GMO is of great concern. See http://www.biox.cn/content/20051128/41159.htm.

[2] For further information, see http://www.oefre.unibe.ch/law/icl/sz00000_.html.

different nature of competition. More specifically, we propose a partial equilibrium model of vertical product differentiation to compare optimal minimum quality standards under social welfare maximization and referendum. These minimum quality standards will also be compared with the one derived under *laisser-faire*, i.e. the unregulated equilibrium.

The topic of this paper is related to the literature of political economics and the literature of trade and industrial organization.

In the theoretical literature of political economics,[3] there are two branches of models that attempt to explain how government policies are formulated. One branch is voting models, and the other is lobbying models. Voting models emphasize that policies are made either directly by citizens or indirectly by representative legislators, while lobbying models stress that the influence of special-interest groups plays a vital role in shaping incumbent government's policy choices. As this paper is along the line of the former, we shall review the literature on the former only.

Voting models can be classified into two groups-- direct democracy and representative democracy. In direct democracy, policies are determined through referendum,[4] and the median voter plays a decisive role (see Black (1948), Mayer (1984), Fernandez and Rodrik (1991), Fuest and Huber (2001), and Chu and Niou (2005)).[5] Equilibrium derived in this way is termed as "preference-induced equilibrium". On the other hand, in representative democracy, policies are made by

[3] Political economics attempts to explain actual policy outcomes using the tools of analysis from economics; see Mueller (1989), Hillman (1989), Persson and Tabellini (2002), Besley and Case (2003).
[4] In a referendum, a policy is normally made by the rule of simple majority, which is based on three assumptions: direct democracy, sincere voting and open agenda. Direct democracy means that citizens make policy choices. Sincere voting implies that,each citizen votes for the policy that gives him the highest utility. Open agenda indicates that citizens vote over pairs of policy alternatives, such that the winning policy in one round is posed against a new alternative in the next round and the entire set of alternatives includes all feasible policies.
[5] Arrow (1951)'s Impossibility Theorem shows that no general rule enables a democracy to consistently aggregate individual preferences into policy choices. However, if we restrict individual policy preferences to a specific form, simple majority rule can generate well-defined equilibrium policies.

legislature and equilibrium derived in this way is called "structure-induced equilibrium" (see Osborne and Slivinski (1996), Persson and Tabellini (2002), Besley and Coate (2003)).

That different competition mode on sales stage can alter equilibrium outcomes has long been marked by Bertrand in the review of the Cournot competition mode.[6] In the 1990s, the comparison of the mode of competition has been extended to the qualitative characteristic of product, i.e. the vertically differentiated product, as the intra-industry trade of qualities increased rapidly (see Fontagne(1998), Aoki(2003), Correa-Lopez(2007) etc.). The literature on vertical product differentiation grows substantially and received much attention, see Choi and Shin (1992), Toshimitsu (2003), Aoki (2003), among others.[7]

However, most of the papers on vertical product differentiation assume that a government acts as a social planner, making policies in pursuit of social welfare maximization (see Ecchia and Lambertini (1997), Valletti (2000), Herguera *et al.* (2002)). This assumption, however, is unrealistic as most countries in the world are democratic and their policies are not formulated in accordance with social welfare maximization. The main purpose of this paper is to take minimum quality standards as an example, to show how different the policy can be if a country takes various decision mechanism such as social welfare maximization and referendum, and compare it with the one under *laisser-faire*, In addition, we shall also explore if the policy ranking is sensitive to competition among firms.

The main result of our paper is that minimum quality standard is higher under social welfare maximization than under referendum when firms engage in Bertrand

[6] The comparison of Cournot and Bertrand in the literature of trade and industrial organization is vivid. See A. Daughety(1988)'s survey in *Cournot Oligopoly: Characterization and Applications*.
[7] This literature can be dated back to the 1970s, see Spence (1975), Sheshinski (1976), Gabszewicz and Thisse (1979) etc..

competition, and the ranking is reversed when firms engage in Cournot competition. In addition, minimum quality standard is higher under referendum than *laisser-faire* no matter firms engage in either Bertrand or Cournot competition.

The remainder of this paper is organized as follows. Section 2 sets up the basic model by assuming firms to take Bertrand fashion and we investigate the minimum quality standards under *laisser-faire*, social welfare maximization and referendum. Section 3 examines the ranking of the standards if the firms play Cournot competition. Section 4 provides the concluding remarks.

2 Minimum quality standards and Bertrand competition

To derive minimum quality standards under different decision mechanisms, we employ the model of vertical product differentiation *a la* Motta (1993), Aoki and Prusa (1996), Zhou *et al*. (2002), and Aoki (2003), among others. In what follows, we shall introduce the basic model when firms compete in Bertrand fashion, and then derive the optimal minimum quality standards under *laisser-faire*, social welfare maximization and referendum respectively.

2.1 The basic model--*Laisser-faire*

The game in this model consists of two stages. In the first stage, each firm chooses the quality level of its product.[8] In the second stage, these two firms engage in Bertrand competition in the output market. We shall use backward induction to derive the subgame perfect Nash equilibrium.

Assume there are two firms, 1 and 2, producing two vertically differentiated products. Firm 1 produces the product with higher quality (henceforth the high-quality

[8] Quality choices can be made simultaneously or sequentially. Institutional factors or government regulations may determine whether the quality competition of firms is simultaneous or sequential. We follow the rather large literature to assume the quality choices of the two firms are made simultaneously. Readers who are interested in sequential quality competition are referred to Aoki and Prusa (1996).

firm), whereas firm 2 produces the product with lower quality (henceforth the low-quality firm). The product qualities of the two firms are denoted as q_1 and q_2, with $q_1 > q_2$. Assume the production cost is zero and the cost of upgrading quality is $k q_i^2/2$, i =1, 2. For simplicity, we assume this cost is the same for the players, a common assumption in the literature(see for example, Motta (1993), Aoki and Prusa (1996), and Aoki (2003).

In the demand side, we assume that there is a continuum of consumers whose types are identified by a taste parameter θ, which is uniformly distributed over the interval [0, 1]. A consumer close to 1 (0) has a higher (lower) affinity to product quality.[9] Assume that each consumer buys at most one unit of either product. Consumers buying the higher quality product, hereafter the high-quality consumers, obtain the surplus as $V_1^i = \theta^i q_1 - p_1$, whereas consumers buying the lower quality product, hereafter the low-quality consumers, obtain $V_2^i = \theta^i q_2 - p_2$. If a consumer buys neither product, he obtains zero surplus.

Given the setting, consumers can be divided into three categories—the high-quality consumers, the low-quality consumers and consumers who buy neither products. Among the consumers, we can identify two marginal consumers. One of them is indifferent between buying high-quality and low-quality products, and the other is indifferent between buying low-quality product and not buying at all. Following Motta (1993), we can derive these two marginal consumers' preferences as $\overline{\theta} = (p_1 - p_2)/(q_1 - q_2)$ and $\underline{\theta} = p_2 / q_2$ respectively.[10] In addition, we can also

[9] Another interpretation of θ is that it is the inverse of the marginal rate of substitution between income and quality. In this view, the higher θ is, the wealthier the consumer becomes. See Tirole (1988, chapter 2).

[10] We have assumed the market is uncovered which implies that not all the consumers are served in equilibrium. This is in contrast to a less popular but easier way of modeling vertical product differentiation by assuming the market is covered. See for example, Ecchia and Lambertini (1997).

derive the demands for the high-quality and the low-quality products as follows:

$$x_1(p_1, p_2) = 1 - \bar{\theta} \,, \tag{1a}$$

$$x_2(p_1, p_2) = \bar{\theta} - \underline{\theta} \,. \tag{1b}$$

Accordingly, the profit functions of the two firms can be specified as follows:

$$\pi_1(p_1, p_2; q_1, q_2) = p_1 x_1 - \frac{k}{2} q_1^{\;2}, \tag{2a}$$

$$\pi_2(p_1, p_2; q_1, q_2, k) = p_2 x_2 - \frac{k}{2} q_2^{\;2} \,. \tag{2b}$$

Taking the product qualities as given, we can differentiate (2) with respect to each firm's price to obtain the first-order conditions for profit maximization as follows:

$$\frac{\partial \pi_i}{\partial p_i} = p_i \frac{\partial x_i}{\partial p_i} + x_i = 0, \quad i = 1, 2. \tag{3}$$

Solving (3) yields the optimal prices which are $p_1 = 2q_1(q_1 - q_2)/(4q_1 - q_2)$ and $p_2 = q_2(q_1 - q_2)/(4q_1 - q_2)$.[11] Substituting these prices into the marginal consumer conditions, we have $\bar{\theta} = (2q_1 - q_2)/(4q_1 - q_2)$ and $\underline{\theta} = (q_1 - q_2)/(4q_1 - q_2)$.

From the marginal consumer condition, we further obtain the sales of the two firms as $x_1 = 1 - \bar{\theta} = 2q_1/(4q_1 - q_2)$ and $x_2 = \bar{\theta} - \underline{\theta} = q_1/(4q_1 - q_2)$. The comparison of the two sale levels leads to the following lemma.

Lemma 1

The market shares of the high-quality and low-quality firms are 2/3 and 1/3 respectively and the resulting *Herfindahl-Hirshman index (HHI)* is 5/9.

[11]The second-order and stability conditions of profit maximization are both satisfied, i.e. $\pi_{1 p_1 p_2} < 0$, $\pi_{2 p_1 p_2} < 0$, and $\pi_{1 p_1 p_2} \pi_{2 p_1 p_2} - \pi_{2 p_1 p_2} \pi_{1 p_1 p_2} > 0$.

It implies that when firms engage in Bertrand competition, the market concentration ratio measured by *HHI* is independent of the product quality levels and the quality upgrading costs.

Furthermore, the optimal qualities are derivable by substituting the prices derived from (3) into the profit functions in (2) and then taking the first derivatives with respect to the qualities. It yields:

$$\frac{\partial \pi_1}{\partial q_1} = \frac{4q_1(4q_1^2 - 3q_1q_2 + 2q_2^2)}{(4q_1 - q_2)^3} - kq_1 = 0, \qquad (4a)$$

$$\frac{\partial \pi_2}{\partial q_2} = \frac{q_1^2(4q_1 - 7q_2)}{(4q_1 - q_2)^3} - kq_2 = 0. \qquad (4b)$$

Solving (4a) and (4b) simultaneously, we obtain $q_1{}^l$ = 0.253311/k and $q_2{}^l = 0.048238/k$, where superscript l denotes the variables associated with *laisser-faire*. This result is consistent with that of Motta (1993) by setting k =1.

2.2 Minimum quality standard and social welfare maximization

In this section, we shall use a model *a la* Ecchia and Lambertini (1997) to derive the MQS which maximizes social welfare.[12] The game now consists of three stages. In the first stage, the government sets an MQS in pursuit of maximum social welfare; in the second stage, both firms determine simultaneously their quality levels subject to the predetermined MQS; finally in the third stage, the two firms compete in a Bertrand fashion. We shall use backward induction to derive the subgame perfect equilibrium. For notational convenience, we shall use superscript w to denote the variables associated with the welfare maximization.

The equilibrium of the third stage (i.e. the market equilibrium of Bertrand

[12] A difference between this model and the one in Ecchia and Lambertini (1997) is that they assume the social planner sets MQS and the high-quality firm chooses its product quality simultaneously, but in our paper, they are done sequentially with the social planner moves first.

competition) is the same as that derived in (3) and shall not be repeated here. The second stage game is for the two firms to choose simultaneously their quality levels subject to the MQS determined by the government in the first stage. In other words, the profit functions of the two firms in the second stage can be specified as follows:

$$\pi_1 = \pi_1(p_1(q_1,\underline{q}), p_2(q_1,\underline{q}), q_1, \underline{q}; k), \tag{5a}$$

$$\pi_2 = \pi_2(p_1(q_1,\underline{q}), p_2(q_1,\underline{q}), q_1, \underline{q}; k). \tag{5b}$$

In (5), $\underline{q}$ represents an MQS. With an MQS constraint, the range of quality available for firms is narrowed—firms can only choose a quality level that is higher than the MQS. We normally expect the MQS to be higher than the quality level of the low-quality firm and lower than the quality level of the high-quality firm.[13] If this is the case, the low-quality firm will be forced to comply with the MQS, i.e. $q_2 = \underline{q}$.[14]

The quality level of the high-quality firm is determined by solving the first-order condition for profit maximization of (5a), which is:

$$\frac{d\pi_1}{dq_1} = \frac{4q_1(4q_1^2 - 3q_1\underline{q} + 2\underline{q}^2)}{(4q_1 - \underline{q})^3} - kq_1 = 0. \tag{6}$$

Furthermore, totally differentiating (6) and rearranging terms, we have:

$$\frac{dq_1}{d\underline{q}} = -\frac{\pi_{1q_1\underline{q}}}{\pi_{1q_1q_1}} > 0, \tag{7}$$

where $\pi_{1q_1q_1} = -8\underline{q}^2(5q_1 + \underline{q})\big/(4q_1 - \underline{q})^4 - k < 0$ and $\pi_{1q_1\underline{q}} = 8q_1\underline{q}(5q_1 + \underline{q})\big/(4q_1 - \underline{q})^4 >$

[13] If the MQS is lower than the quality level of the low-quality firm under *laisser-faire* (i.e. $\underline{q} < q_2^l$), then the quality policy is ineffective and futile. If the MQS is higher than the quality level of the high-quality firm under *laisser-faire* (i.e. $\underline{q} > q_1^l$), then the firms are forced to choose the same MQS and earns zero profits.

[14] We prove in Appendix 1 that the welfare-maximizing MQS is indeed higher than the quality level of the low-quality firm under *laisser-faire* when firms compete in Bertrand fashion.

0.[15] The sign of (7) indicates that the quality level of the high-quality firm increases as the MQS becomes higher.

Now let us turn to the first-stage problem. In this stage, the government sets an MQS to maximize social welfare (*SW*) which is composed of consumer surplus and producer surplus, i.e. $SW = \int_{p_2/\underline{q}}^{(p_1-p_2)/(q_1-\underline{q})} (\theta \underline{q} - p_2) d\theta + \int_{(p_1-p_2)/(q_1-\underline{q})}^{1} (\theta q_1 - p_1) d\theta + \pi_1 + \pi_2$ where the first two terms of the welfare function represent the consumer surplus generated from the low and the high quality products respectively. The welfare-maximizing MQS is derived by maximizing the social welfare function with respect to $\underline{q}$ as follows:

$$\frac{dW}{d\underline{q}} = \frac{\partial W}{\partial q_1}\frac{dq_1}{d\underline{q}} + \frac{\partial W}{\partial \underline{q}} = 0. \tag{8}$$

Utilizing (7), we can solve (8) to obtain the welfare-maximizing MQS as follows:

$$\underline{q}^{w} = 0.170216/k. \tag{9a}$$

As mentioned before, this is also the quality level of the low-quality firm. Moreover, substituting (9a) into (6) yields the optimal quality of the high-quality firm (denoted by q_1^w) given the welfare-maximizing MQS as follows:

$$q_1^w = 0.293324/k. \tag{9b}$$

Comparing (9) to those derived under *laisser-faire*, we can easily conclude that the product qualities under welfare maximizing MQS are greater than the counterparts under *laisser-faire*.

2.3 Referendum

15 Since $\pi_{1q_1q_1} < 0$, the second-order condition for profit maximization is satisfied.

In this section, we shall derive the optimal MQS under referendum and compare it to that under welfare maximization. Following the literature on referendum, we assume that every voter will honestly cast his vote for his most preferred candidate (issue), ruling out the possibility of strategic voting.[16]

As before, the game consists of three stages. In the first stage, an MQS is determined by referendum, i.e. by a majority of voters. In the second stage, firms decide on their product qualities subject to the MQS, and in the third stage, firms compete in Bertrand fashion. As the equilibria of the last two stages are the same as those prevailing in (3), (5), (6) and (7), we need only to work out the MQS in the first stage.

If every voter has a single-peaked preference over a set of policies, the winning policy always exists and coincides with the median voter's preference in a pairwise voting. Hence, the median voter plays a decisive role under a referendum.

We can infer from Lemma 1 that the high-quality firm secures more than half of the market. Hence, the median voter must be one of the consumers purchasing the high-quality product. Let us identify this consumer by superscript *m*. His surplus is written as $V_1^m = \theta^m q_1 - p_1$ and an increase of MQS yields the following effect on his surplus:

$$\frac{dV_1^m}{d\underline{q}} = \left(\theta^m - \frac{\partial p_1}{\partial q_1}\right)\underbrace{\frac{dq_1}{d\underline{q}}}_{+} - \underbrace{\frac{\partial p_1}{\partial \underline{q}}}_{-} \tag{10}$$

If $\theta^m > \partial p_1 / \partial q_1$, (10) is definitely positive, meaning that an increase of MQS makes the median voter better off. On the contrary, the sign of (10) is ambiguous if

[16] Voters may cast their votes strategically. For instance, they may not waste their votes on a candidate who has little chance of winning, even if the candidate is their favorite. See Gibbard (1973), Satterthwaite (1975), Chen and Yang (2002) for further discussions.

$\theta^m < \partial p_1 / \partial q_1$.[17] However, the majority constituted by all the low-quality consumers and the high-quality consumers whose taste preference is higher than $\partial p_1 / \partial q_1$ prefer for the highest possible quality.[18] Hence, the majority of voters prefer the highest level of MQS which is the quality that drives the profit of the low-quality firm to zero.[19] In other words, the MQS is determined by the zero-profit condition of the low-quality firm.

Substituting the result derived from (6) into the zero-profit condition of the low-quality firm, we obtain the optimal MQS under the decision mechanism of referendum as follows:

$$\underline{q}^r = 0.0961877 / k . \quad (11a)$$

To facilitate the comparison, we use superscript *r* to denote the variables associated with referendum. Substituting (11a) into (6) yields:

$$q_1^r = 0.264057 / k . \quad (11b)$$

We shall compare the quality with that under welfare maximization (i.e. (9)) or *laisser-faire* (i.e. (4)) in section 2.4.

2.4 The ranking of MQS under various decision mechanisms

This section aims to compare the MQS under *laisser-faire*, social welfare

17 $\partial p_1 / \partial q_1 = (8 q_1^2 - 4 q_1 \underline{q} + 2 \underline{q}^2) / (4 q_1 - \underline{q})^2$. Even the sign may be ambiguous. We show in Appendix 2 that the high-quality and low-quality consumers are both single-peaked in equilibrium.

18 The number of consumers who prefer the highest possible quality is greater than half of all the consumers, i.e. $\overline{\theta} - \underline{\theta} + 1 - \partial p_1 / \partial q_1 > 0.5$.

19 The high-quality consumers benefit more when the market remains of duopoly than when the market is of monopoly. When the market is monopolistic, the highest possible surplus for citizen *i* is $V^i = (\theta^i - 0.5) 0.5 / k$. On the other hand, when the product market remains to be of duopoly, the majority of consumers prefer the highest possible quality. The surplus of high-quality consumer is $V^i = \theta^i 0.264057 / k - 0.0923439 / k$. By comparing the surplus under these two situations, we obtain that when $\theta^i >$ ($<$) 0.668, consumer *i* is better off if the market is monopolistic(duopolistic). In addition, the median voter when market remain duopolistic is $(1 + \underline{\theta}) / 2$ =0.587428 which is smaller than 0.668. Hence, it is better off for the median voter to pick a highest quality level that with two firms staying in business rather than with only the high-quality firm monopolizing the market.

maximization and referendum. From (4), (9) and (11), we can establish the following proposition.

Proposition 1

Assume the firms in the product market play Bertrand competition. The ranking of the optimal MQS under *laisser-faire*(*l*), social welfare maximization(*w*) and referendums(*r*), is $\underline{q}^w > \underline{q}^r > q_2^l$.

The intuition of the proposition is as follows. Normally we expect the impulse of social welfare pushes the MQS up, making the quality standards under social welfare maximization go higher than that under *laisser-faire*. This contemplation sustains here because an increase of MQS above the *laisser-faire* level improves consumer surplus and the profit of low-quality firm and these forces hence push up the MQS even though a higher MQS decreases the profit of high-quality firm.[20] Moreover, the quality standard under referendum is the quality that drives the profit of low-quality firm to zero. It is then obvious that $\underline{q}^r > q_2^l$. Finally, the low quality and high quality consumers are always better off from a higher MQS and since MQS under referendum is bounded by the zero-profit condition of low-quality firm, therefore the MQS of social welfare maximization is higher than that of referendums.

Oates(1972) proposed the renowned Decentralization Theorem that a decentralized system is preferred than centralized system for a public good because a decentralized system produces an outcome that reflects local needs while a centralized

[20] The high-quality firm is worse off with an increase of MQS as $d\pi_1 / d\underline{q} = 4q_1^2(-2q_1 - \underline{q})/(4q_1 - \underline{q})^3 < 0$. However, the low-quality firm is better off when MQS is close to q_2^l as $d\pi_2 / d\underline{q} = \partial\pi_2/\partial\underline{q}\,\partial q_1/\partial\underline{q} + \partial\pi_2/\partial\underline{q} > 0$, see Ronnen (1991) for more rigorous discussions.

system does not. In this paper we depicted centralized system as the decision mechanism of social welfare maximization and decentralized system as of referendum. When firms compete in Bertrand fashion, rather than decentralized system, centralized system should be preferable in the sense that centralized system generates a higher quality standard.

3 MQS and Cournot Competition

In this section, we shall assume firms in the market play Cournot competition and re-examine the ranking of quality policy. The game structures under *laisser-faire*, referendum and social welfare maximization are the same as before and thus are saved for simplicity.

3.1 ***Laisser-faire***

From demands in (1), we can derive the inversed market demands as $p_1 = q_1 - q_1 x_1 - q_2 x_2$ and $p_2 = q_2(1 - x_1 - x_2)$. Substituting the inversed demands into (2) and then differentiating it with respect to output, we have the first-order conditions for profit maximization as follows:

$$\partial \pi_1 / \partial x_1 = q_1 - 2q_2 x_1 - q_2 x_2 = 0, \tag{12a}$$

$$\partial \pi_2 / \partial x_2 = q_2(1 - x_1 - 2x_2) = 0. \tag{12b}$$

Solving (12) simultaneously, the equilibrium outputs as a function of the quality level are as follows:

$$x_1^c = (2q_1 - q_2)/(4q_1 - q_2), \tag{13a}$$

$$x_2^c = q_1/(4q_1 - q_2). \tag{13b}$$

The superscript *c* denotes variables associated with Cournot competition. From (13), we obtain the *Herfindahl* index as $HHI^c = (5q_1^2 - 4q_1 q_2 + q_2^2)/(3q_1 - q_2)^2$.

This leads to the following lemma.

Lemma 2

***HHI**^c* **increases (decreases) as the high-quality (low-quality) firm raises its quality.**

As expected, the market share of the high-quality firm is larger than that of the low-quality firm. However, the market concentration ratio measured by HHI^c under Cournot competition is in sharp contrast from that under Bertrand competition. When firms engage in Cournot competition, the HHI^c is not a fixed constant as in the case of Bertrand competition. In fact, it is positively (negatively) related to the quality level of the high-quality (low-quality) firm.[21]

The reason for lemma 2 is that when the high-quality (low-quality) firm raises its quality, the market share of the high-quality firm increases (decreases) and the market becomes more (less) concentrated toward the high-quality firm. Therefore, the HHI^c increases (decreases) when the high-quality (low-quality) firm raises its quality.

The first stage equilibrium, on the other hand, can be derived by substituting (13) into (2) and then taking the first derivative with respect to qualities which leads to the following:

$$\frac{\partial \pi_1{}^c}{\partial q_1} = \frac{16q_1^3 - 12q_1^2 q_2 + 4q_1 q_2^2 - q_2^3}{(4q_1 - q_2)^3} - kq_1 = 0\,, \tag{14a}$$

$$\frac{\partial \pi_2{}^c}{\partial q_2} = \frac{q_1^2(4q_1 + q_2)}{(4q_1 - q_2)^3} - kq_2 = 0 \quad . \tag{14b}$$

From (14), we obtain the equilibrium qualities under Cournot-Nash competition as $q_1^{cl} = 0.251942/k$ and $q_2^{cl} = 0.0902232/k$. This result is consistent to Motta

[21] $dHHI^c/dq_1 = 2q_2(q_1 - q_2)/(3q_1 - q_2)^3 > 0$ and $dHHI^c/dq_2 = -2q_1(q_1 - q_2)/(3q_1 - q_2)^3 < 0$.

(1993) after setting $k = 1$.

3.2 Social welfare maximization

As before, the game consists of three stages. The output equilibrium of the third stage is the same as those prevailing in (13). As we assume the MQS constraint to be effective, the optimal quality of the low quality firm must be identical to the MQS. Given this assumption, the optimal quality of the high-quality firm in contrast is derivable by substituting the MQS into (14a). That is:

$$\frac{\partial \pi_1^c}{\partial q_1} = \frac{16 q_1^3 - 12 q_1^2 \underline{q}^c + 4 q_1 \underline{q}^{c2} - \underline{q}^{c3}}{(4 q_1 - \underline{q}^c)^3} - k q_1 = 0 , \tag{15}$$

where $\underline{q}^c$ represents the MQS set by the government when firms compete in Cournot fashion.

Totally differentiating (15) with respect to q_1 and $\underline{q}^c$, we obtain the influence of an increase of MQS on the quality level of the high-quality firm as follows:

$$\frac{dq_1}{d\underline{q}^c} = -\frac{\pi^c_{1 q_1 \underline{q}^c}}{\pi^c_{1 q_1 q_1}} > 0 . \tag{16}$$

Since $\pi^c_{1 q_1 \underline{q}^c} = 8 q_1 \underline{q}^c (q_1 - \underline{q}^c) \big/ (4 q_1 - \underline{q}^c)^4 > 0$ and $\pi^c_{1 q_1 q_1} = -8 \underline{q}^{c2} (q_1 - \underline{q}^c) \big/ (4 q_1 - \underline{q}^c)^4 - k < 0$, the sign of (16) is positive, showing that the high-quality firm increases its quality with a higher MQS.

The first-stage of the game is to derive the welfare-maximizing MQS. The social welfare function here is the same as the one we have used to derive the MQS under Bertand competition which again is :

$$SW = \int_{p_2/\underline{q}}^{(p_1 - p_2)/(q_1 - \underline{q})} (\theta \underline{q} - p_2) d\theta + \int_{(p_1 - p_2)/(q_1 - \underline{q})}^{1} (\theta q_1 - p_1) d\theta + \pi_1 + \pi_2 .$$

Substituting inversed market demand and (13) into the welfare function yields:

$$SW = \frac{q_1(12q_1^{\ 2} - 5q_1\underline{q}^c + \underline{q}^{c2})}{2(4q_1 - \underline{q}^c)^2} - \frac{k}{2}q_1^{\ 2} - \frac{k}{2}\underline{q}^{c2}. \tag{17}$$

Differentiating (17) with respect to MQS, we obtain the first-order condition for welfare maximization as follows:

$$\frac{dSW}{d\underline{q}^c} = \frac{\partial SW}{\partial q_1}\frac{dq_1}{d\underline{q}^c} + \frac{\partial SW}{\partial \underline{q}^c}$$

$$= \left[\frac{(48q_1^3 - 36q_1^2\underline{q}^c + 6q_1\underline{q}^{c2} - \underline{q}^{c3})}{2(4q_1 - \underline{q}^c)^3} - kq_1\right]\frac{dq_1}{d\underline{q}^c} + \left[\frac{q_1^2(4q_1 + 3\underline{q}^c)}{2(4q_1 - \underline{q}^c)^3} - k\underline{q}^c\right] = 0$$

Solving the above first-order condition, we obtain the welfare-maximizing MQS under Cournot competition as follows:

$$\underline{q}^{cw} = 0.0427793/k. \tag{18a}$$

Substituting (18a) into (15), we obtain the equilibrium quality of high-quality firms as follows:

$$q_1^{cw} = 0.250453/k. \tag{18b}$$

The MQS in (18a) will be compared with those derived under *laisser-faire* and under referendum in Section 3.4.

3.3 Referendum

The game structure in this sub-section is the same as that in Section 2.2 except for the competition mode being Cournot fashion. The equilibrium in the second stage and the last stage are the same as those derived under *laisser-faire* in Section 3.1. Let us solve directly to the first stage equilibrium. Under referendum, the optimal policy is identical to the one preferred by the median voter.[22] For this end, we shall first examine the influence of MQS on the surplus of consumers.

[22] In Appendix 3, we prove that the preference of all the consumers is single-peaked.

An increase in MQS has the following effect on the high-quality consumers:

$$\frac{dV_1^{\ m}}{d\underline{q}} = \theta^m \frac{dq_1}{d\underline{q}} - \frac{dq_1}{d\underline{q}} + \frac{dq_1}{d\underline{q}} x_1 + q_1 (\frac{\partial x_1}{\partial q_1}\frac{dq_1}{d\underline{q}} + \frac{\partial x_1}{\partial \underline{q}}) + q_2 (\frac{\partial x_2}{\partial q_1}\frac{dq_1}{d\underline{q}} + \frac{\partial x_2}{\partial \underline{q}}) + x_2$$

$$= \underbrace{\left[\theta^m - \frac{(8q_1^{\ 2} - 4q_1\underline{q} + \underline{q}^2)}{(4q_1 - \underline{q})^2}\right]}_{+} \underbrace{\frac{dq_1}{d\underline{q}}}_{+} + \underbrace{\frac{2q_1^{\ 2}}{(4q_1 - \underline{q})^2}}_{+} > 0 \,. \tag{19}$$

The sign of (19) is positive because for the m^{th} high-quality consumer, his quality preference belongs to the region, $\theta^m \in [\overline{\theta}, 1]$, and $\overline{\theta} > (8q_1^{\ 2} - 4q_1\underline{q} + \underline{q}^2) / (4q_1 - \underline{q})^2$. Given the assumption that consumers who do not buy either product abstain from voting, it is clear from (13) that the number of the high-quality consumers outweighs that of the low-quality consumers and thus the outcome of the referendum is identical to the quality level which maximizes the surplus of the high-quality consumers. Moreover, by (19), high-quality consumers always enjoy better with an increase of MQS. Following the same logic in Section 2.3, we can obtain the optimal MQS under referendum as $\underline{q}^{cr} = 0.18667/k$. Substituting this into (15), we can derive the quality of the high-quality firm as follows: $q_1^{cr} = 0.256852/k$.

3.4 The ranking of MQS

In this section, we shall compare the MQS under *laisser-faire*, welfare maximization and referendum given that firms engage in Cournot competition. As the MQS under these scenarios are respectively $q_2^{cl} = 0.0902232/k$, $\underline{q}^{cw} = 0.0427793/k$ and $\underline{q}^{cr} = 0.18667/k$, we can establish the following proposition.

Proposition 2

Assume firms in the market play Cournot competition. The ranking of the optimal MQS under *laisser-faire* (*l*), social welfare maximization (*w*) and referendums (*r*), is $\underline{q}^{cr} > q_2^{cl} > \underline{q}^{cw}$.

Proposition 2 shows that if firms play Cournot competition in sale market, the optimal MQS is higher under referendum than under social welfare maximization and the one under *laisser-faire* falls in-between the two MQS. Two remarks are warranted here. First, this result is in sharp contrast to the finding of Proposition 1 of which the welfare-maximizing MQS is higher than the *laisser-faire* quality when the firms engage in Bertrand competition. This finding confirm Ronnen's(1991) doubt that the effects on MQS under Bertrand competition may not be carried over to Cournot competition as the firms face less competition. Second, Proposition 2 indicates that the welfare-maximizing MQS (i.e. $\underline{q}^{cw}$) is lower than the *laisser-faire* quality of the low-quality firm (i.e. q_2^{cl}) meaning that MQS policy is ineffective if the objective of a country is to maximize social welfare when firms play Cournot competition. In other words, this MQS should not be adopted when firm play Cournot competition.

From Proposition 1 and 2, it is clear that introducing a stricter MQS policy may not necessarily improve social welfare. To ensure the policy benefits all society, the government should thoroughly investigate the industry-specific characteristics, for instance whether the mode of competition among firms is over prices or over quantities, before making its policies. Moreover, we also find that the optimal MQS is lower under referendum than under social welfare maximization if firms engage in Bertrand competition; it is yet higher in Cournot competition. This outcome can be used to explain why governments in a democratic society fail to adopt efficiency-enhancing policies. Fernandez and Rodrik (1991) has mentioned that when facing a political reform the weight that gainers and losers receive constitutes a reason why government fail to adopt efficiency-enhancing policies.[23] In this paper, when policies are made by the majority of the people, the referendum outcome is different from the efficient outcome as the majority-preferred MQS is higher (lower) than the efficient one when firms compete over quantities (prices).

4 Concluding remarks

During the last two decades, many countries have shifted from a centralized economy to a decentralized one. This institutional change shows that the traditional welfare maximization approach in determination of economic policies may not fit the reality and therefore deserves more scholarly attention. In this paper, we have used minimum quality standard as an example to compare the equilibria under various decision mechanisms, such as referendum and social welfare maximization, and various competition modes, such as Bertrand and Cournot, and compare them to those under *laisser-faire*.

This paper has shown that the ranking of minimum quality standards under different decision mechanisms is sensitive to the competition mode of the firms. If the firms engage in Bertrand competition, the minimum quality standard under welfare maximization is the highest, followed by that under referendum, and then under *laisser-faire*. In contrast, if the firms play Cournot competition, the minimum quality standard under referendum is the highest, followed by that under *laisser-faire* and then by that under social welfare maximization.

Oates' Decentralization Theorem states that a decentralized system is preferable than centralized system, since in a centralized system it produces an outcome that

[23] Fernandez and Rodrik (1991) referred to the uncertainty regarding the distribution of gains and losses from reform as one of the nonneutralities.

does not reflect local needs. Our results do not support the Decentralization Theorem, however. We have shown that a centralized system represented by the decision mechanism of social welfare maximization, may be more desirable in upgrading product qualities than a decentralized system represented by referendum when firms engage in an intense competition such as Bertrand competition.

Appendix 1

Appendix 1 compares the MQS under social welfare maximization and that under *laisser-faire* when firms engage in Bertrand competition. Making use of Envelope theorem and collecting terms, the welfare-maximizing MQS is derivable by setting (8) to zero:

$$\frac{dW}{d\underline{q}}=\{\frac{1}{2(4q_1-\underline{q})^3}[(36q_1^{\ 2}-2q_1\underline{q}-2\underline{q}^2)(4q_1-\underline{q})-8(12q_1^{\ 3}-q_1^{\ 2}\underline{q}-2q_1\underline{q}^2)]\frac{dq_1}{d\underline{q}}-kq_1\frac{dq_1}{d\underline{q}}\}$$

$$+\{\frac{1}{2(4q_1-\underline{q})^3}[(-q_1^{\ 2}-4q_1\underline{q})(4q_1-\underline{q})+2(12q_1^{\ 3}-q_1^{\ 2}\underline{q}-2q_1\underline{q}^2)]-kq_2\}. \qquad \text{(A1)}$$

To compare the MQS with that of *laisser-faire*, we evaluate (A1) at the quality of *laisser-faire* as follows:

$$\left.\frac{dW}{d\underline{q}}\right|_{\underline{q}=q_2^l}=\frac{(2q_1+q_2^l)(q_1-q_2^l)}{(4q_1-q_2^l)^2}\frac{dq_1}{d\underline{q}}+\frac{3q_1^{\ 2}}{2(4q_1-q_2^l)^2}>0. \qquad \text{(A2)}$$

The sign of (A2) is positive since $q_1>q_2^l$ and $dq_1/d\underline{q}>0$ by (7). This means that the welfare-maximizing MQS is greater than the quality level of the low-quality firm under *laisser-faire*.

Appendix 2

The purpose of this appendix is twofold: Derive (i) the effect of MQS on prices, (ii) the effect of MQS on the surplus of high-quality consumers, and (iii) the effect of

MQS on the surplus of low-quality consumers.

(i) Substituting the result derived from (6) into optimal prices(derivable from (2)) and making use of (7), we obtain the impact of MQS on prices of the two products as follows:

$$\frac{dp_1}{d\underline{q}} = \frac{\partial p_1}{\partial q_1}\frac{dq_1}{d\underline{q}} + \frac{\partial p_1}{\partial \underline{q}} = \frac{-2q_1(3kq_1(4q_1-\underline{q})^3 - 8\underline{q}(5q_1^{\,2} - 4q_1\underline{q} - \underline{q}^2))}{(4q_1-\underline{q})(k(4q_1-\underline{q})^4 + 8\underline{q}^2(5q_1+\underline{q}))} \tag{A3}$$

$$\frac{dp_2}{d\underline{q}} = \frac{\partial p_2}{\partial q_1}\frac{dq_1}{d\underline{q}} + \frac{\partial p_2}{\partial \underline{q}} = \frac{k(4q_1-\underline{q})^3(4q_1^{\,2} - 8q_1\underline{q} + \underline{q}^2) + 8\underline{q}^2(5q_1^{\,2} - 4q_1\underline{q} - \underline{q}^2))}{(4q_1-\underline{q})(k(4q_1-\underline{q})^4 + 8\underline{q}^2(5q_1+\underline{q}))} \tag{A4}$$

(ii) The surplus of the high-quality buyers is defined as $V_1^{\,i} = \theta^i q_1 - p_1$. An increase in MQS has the following impact on the high-quality buyer:

$$\frac{dV_1^{\,i}}{d\underline{q}} = \theta^i\frac{dq_1}{d\underline{q}} - (\frac{\partial p_1}{\partial q_1}\frac{dq_1}{d\underline{q}} + \frac{\partial p_1}{\partial \underline{q}}) = (\theta^i - \frac{\partial p_1}{\partial q_1})\underbrace{\frac{dq_1}{d\underline{q}}}_{+} - \underbrace{\frac{\partial p_1}{\partial \underline{q}}}_{-} \tag{A5}$$

if $\theta^i > \partial p_1/\partial q_1$, the sign of (A5) is positive, implying that an increase of MQS raises the utility of high-quality buyer and hence the preference is single-peaked. On the other hand, if $\theta^i < \partial p_1/\partial q_1$, the sign of (A5) is uncertain. In the latter case, we should check whether the preference of high-quality consumers is single-peaked.

Totally differentiating (A5), we obtain the following:

$$\frac{\partial^2 V_1^{\,i}}{\partial \underline{q}^2} = (\theta^i - \frac{\partial p_1}{\partial q_1})(\frac{\partial^2 q_1}{\partial \underline{q}\partial q_1}\frac{\partial q_1}{\partial \underline{q}} + \frac{\partial^2 q_1}{\partial \underline{q}^2}) + (-\frac{\partial^2 p_1}{\partial q_1\partial \underline{q}} - \frac{\partial^2 p_1}{\partial q_1^{\,2}}\frac{dq_1}{d\underline{q}})\frac{dq_1}{d\underline{q}}$$
$$-(\frac{\partial^2 p_1}{\partial q_1\partial \underline{q}}\frac{dq_1}{d\underline{q}} + \frac{\partial^2 p_1}{\partial \underline{q}^2}). \tag{A6}$$

Making use of (A3), (A4) and (7), and then collecting terms, we have:

$$\frac{\partial^2 V_1^{\,i}}{\partial \underline{q}^2} = -6kq_1^{\,2}(4q_1-\underline{q}^2)[400q_1^{\,5}(k-\underline{q}^2/q_1^{\,3}) + 160q_1^{\,5}(k-\underline{q}^3/q_1^{\,4}) + 16q_1^{\,5}(k-\underline{q}^4/q_1^{\,5})$$

$$+179kq_1^{\,5} + 128kq_1^{\,4}(q_1-\underline{q}) + 384kq_1^{\,3}(q_1^{\,2}-\underline{q}^2) + 13kq_1(q_1^{\,4}-\underline{q}^4) + 136kq_1^{\,2}\underline{q}^3]$$

$$\div\underbrace{[\underline{q}(5q_1+\underline{q})(256kq_1^{\,4} - 256kq_1^{\,3}\underline{q} + 96kq_1^{\,2}\underline{q}^2 + 8q_1\underline{q}(5-2k\underline{q}) + q^3(8+k\underline{q}))^2]}_{+} \tag{A7}$$

The denominator of (A7) is positive and if $k > \underline{q}^2 / q_1^3$ the square bracket of the numerator is positive. From (11), we conclude that (A7) is negative, implying that the preference of high-quality consumers is single-peaked in equilibrium.

(iii)The consumer surplus of the low-quality product is defined as $V_2^i = \theta^i \underline{q} - p_2$.

Taking its first derivative with respect to MQS, we have:

$$\frac{dV_2^i}{d\underline{q}} = \theta^i - \frac{dp_2}{d\underline{q}} > 0 \tag{A8}$$

The sign of (A8) is positive because of the following two reasons. First, the low-quality consumer *i* locates in the region between $\underline{\theta}$ and $\overline{\theta}$. Second, even if its preference(θ^i) locates at the lowest end (i.e. $\underline{\theta}$), the following inequality holds: $\underline{\theta}$ $> dp_2 / d\underline{q}$ because $\underline{\theta}$ - $dp_2 / d\underline{q} = 3kq_1\underline{q}(4q_1 - \underline{q})^2 / [k(4q_1 - \underline{q})^4 + 8\underline{q}^2(5q_1 + \underline{q})] >$ 0. Hence, we conclude that the low-quality buyers are better off as the MQS grows higher. Furthermore, (A8) also indicates that the preference of the low-quality consumers is absolutely single-peaked.

Appendix 3

Appendix 3 shows that the preference of the high-quality and low-quality consumers is single-peaked when firms engage in Cournot competition. First note that because (19) is positive, the preference of the high-quality customers is naturally single-peaked. In the following, we only have to prove that the preference of low-quality consumers is single-peaked.

An increase of MQS has the impact on low-quality consumers as: $\frac{dV_2^i}{d\underline{q}} = \frac{\partial V_2^i}{\partial q_1}\frac{dq_1}{d\underline{q}} + \frac{\partial V_2^i}{\partial \underline{q}}$. Totally differentiating this equation with respect to $\underline{q}$, we obtain the second-order condition for the utility of low-quality consumer as follows:

$$\frac{\partial^2 V_2{}^i}{\partial \underline{q}^2} = (\frac{\partial^2 V_2{}^i}{\partial q_1{}^2}\frac{dq_1}{d\underline{q}} + \frac{\partial^2 V_2{}^i}{\partial q_1 \partial \underline{q}})\frac{dq_1}{d\underline{q}} + \frac{\partial V_2{}^i}{\partial q_1}(\frac{\partial^2 q_1}{\partial \underline{q}^2} + \frac{\partial^2 q_1}{\partial q_1 \partial \underline{q}}\frac{dq_1}{dq_2}) + (\frac{\partial V_2{}^i}{\partial \underline{q}\partial q_1}\frac{dq_1}{d\underline{q}} + \frac{\partial^2 V_2{}^i}{\partial \underline{q}^2})$$

$$= -8kq_1(4q_1 - \underline{q})^2 \left[k^2 q_1(4q_1 - \underline{q})^7 + 16(q_1 - \underline{q})^2 \underline{q}^4 + k(4q_1 - \underline{q})^3 \underline{q}^2 (4q_1{}^2 - 3q_1\underline{q} + 2\underline{q}^2)\right]$$

$$\div \left[8(q_1 - \underline{q})\underline{q}^2 + k(4q_1 - \underline{q})^4\right]^3 < 0 .$$

The negative sign of the above equation means that the preference of the low-quality consumers is single-peaked.

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